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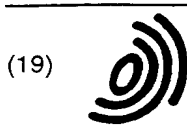
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(54) Pneumatic tyre for passenger cars and method of manufacture thereof

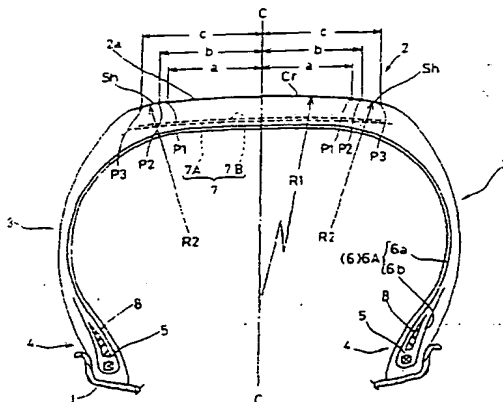
(57) A pneumatic tyre for passenger cars which is improved in harshness noise without deteriorating the steering stability is disclosed, wherein a harshness factor HF is set in the range of from 3.2 to 3.5, the harshness factor HF being:

$$0.183X(Kv/10)+3.898$$

$$HF=-0.133X(R1/100)+0.245X(R1/R2)-$$

where R1 is a radius of curvature (mm) of a crown part (Cr) of the tread profile, R2 is a radius of curvature (mm) of shoulder parts (Sh) of the tread profile, and Kv is the vertical spring constant (KN/mm) of the tyre.

Fig.1



## Description

[0001] The present invention relates to a pneumatic tyre for passenger cars in which a novel harshness factor is specifically defined to reduce harshness noise without deteriorating steering stability.

[0002] When a passenger car runs on paved roads having joints, humps, hollows and the like, the shocks thereby are transmitted from the tyres to the inside of the car through the suspension mechanisms and felt as sound as well as shocks. This sound is called 'harshness noise'.

[0003] The harshness noise can be reduced by using a relatively soft tread rubber for example. In this case however, the steering stability decreases.

[0004] It is therefore an object of the present invention to provide a pneumatic tyre for passenger cars in which the harshness noise is reduced without deteriorating the steering stability.

[0005] According to the present invention a pneumatic tyre for passenger cars comprises a tread portion, and when the tyre is mounted on a regular rim, inflated to 200 KPa and loaded with no tyre load, the tread portion has a profile comprising a crown part having a radius of curvature R1 (mm) and shoulder parts each having a radius of curvature R2 (mm), where the crown part is defined as extending from the tyre equator to an axial position on each side thereof spaced at an axial distance of 35 % of tread width from the tyre equator, and each shoulder part is defined as extending on one side of the tyre equator from an axial position spaced at an axial distance of 37.5 % of the tread width from the tyre equator to an axial position spaced at an axial distance of 45 % of the tread width from the tyre equator, wherein a harshness factor HF is set in the range of from 3.2 to 3.5, where the harshness factor HF is defined as

$$HF = -0.133X(R1/100) + 0.245X(R1/R2) - 0.183X(Kv/10) + 3.898$$

and Kv is the vertical spring constant (KN/mm) of the tyre.

[0006] The 'tread width TW' is the maximum axial width of the ground contacting area under a standard condition in which the tyre is mounted on its regular rim and inflated to a standard pressure of 200 KPa and then loaded with a normal load W0. The 'regular rim' is the rim officially approved for the tyre by a standard organisation, i.e. JATMA (Japan and Asia), T&RA (North America), ETRTO (Europe), STRO (Scandinavia) and the like. The normal load W0 is 75% of the maximum load specified by the same organisation. Incidentally, the reason why 200 KPa is used is that this value is typical of almost all tyre sizes as the service pressure.

[0007] The inventors discovered that the harshness noise of passenger car tyres can be reduced by optimising the relationship between the tread crown radius, the tread shoulder radius and the tyre vertical spring constant, and that it is effective to limit the newly established harshness factor HF into a specific range. If the harshness factor HF is less than 3.2, the harshness noise is decreased effectively. If the harshness factor HF is more than 3.5, the steering stability deteriorates.

[0008] An embodiment of the present invention will now be described in detail in conjunction with the accompanying drawings:

Fig.1 is a cross sectional view of a pneumatic tyre for passenger cars showing an embodiment of the present invention; and

Fig.2 is a graph showing a relationship between tyre load and vertical deflection;

[0009] In Fig.1, a passenger pneumatic tyre according to the invention comprises a tread portion 2; a pair of bead portions 4 each with a bead core 5 therein, a pair of sidewall portions 3, a carcass 6 extending between the bead portions, and a belt 7 disposed radially outside the carcass 6 in the tread portion.

[0010] The carcass 6 comprises at least one ply reinforced by cords arranged radially at an angle of from 75 to 90 degrees with respect to the tyre equator C and extending between the bead portions 4 through the tread portion 2 and sidewall portions 3 and turned up around the bead cores 5 in the bead portions to form a pair of turnup portions 6b and a main portion 6a therebetween. In this embodiment, the carcass is composed of a single ply of cords arranged at substantially 90 degrees. Thus, the tyre is a radial tyre. For the carcass cords, organic fibre cords, e.g. polyester, nylon, rayon and aromatic polyamid and the like and steel cords can be used. In this embodiment, polyester cords are used. Between the main portion 6a and each turnup portion 6b, a bead apex 8 is disposed made of hard rubber and extending radially outwardly from the bead core 5.

[0011] The belt 7 comprises a breaker and optionally a band or bandage. The breaker is composed of at least two crossed plies each made of parallel cords laid at an angle of from 15 to 40 degrees with respect to the tyre equator. The band is composed of at least one cord ply the cord angle of which is substantially zero with respect to the tyre equator. In this embodiment, the belt is composed of two crossed breaker plies, a radially inner ply 7A and a radially outer ply 7B slightly narrower than the inner ply 7A. For the belt cords, steel cords and high elastic modulus organic

fibre cords, e.g. aramid, rayon and the like can be used. In this embodiment, steel cords are used.

[0012] Under the normally-inflated unloaded state in which the tyre is mounted on the regular rim J, inflated to 200 KPa and loaded with no tyre load, the tread portion 2 has a profile 2a comprising a crown part Cr which is convex and which has a radius of curvature R1 (mm) and shoulder parts Sh each of which is convex and has a radius of curvature R2 (mm). The crown part Cr is defined as extending from the tyre equator C to an axial position P1 on each side thereof spaced at an axial distance (a) of 35 % of the tread width TW from the tyre equator C. The shoulder part Sh is defined as extending on one side of the tyre equator from an axial position P2 spaced at an axial distance (b) of 37.5 % of the tread width TW from the tyre equator C to an axial position P3 spaced at an axial distance (c) of 45 % of the tread width TW from the tyre equator C.

[0013] Preferably, the crown radius R1 is set in the range of from 2 to 10 times the tread width TW, and the shoulder radius R2 is set in the range of from 1 to 5 times the tread width TW. Usually,  $R1 > R2$ , and each of the crown part and shoulder parts has a single radius curvature.

[0014] With a crown radius R1 (mm) and shoulder radius R2 (mm) and a vertical spring constant Kv (KN/mm) of the tyre, the harshness factor HF is defined as

$$HF = -0.133 \times (R1/100) + 0.245 \times (R1/R2) - 0.183 \times (Kv/10) + 3.898$$

[0015] The vertical spring constant Kv is defined as

$$Kv = 2.0 / (Z2 - Z1)$$

wherein the vertical deflections Z1 and Z2 (mm) of the tyre, mounted on its regular rim J and inflated to 200 KPa, are those measured while the tyre load is varied plus/minus 1.0 KN from a normal load W0 as shown in Fig.2, and Z1 is the vertical deflection in mm under the minus 1 KN condition and Z2 is the vertical deflection in mm under the plus 1 KN condition.

[0016] In the present invention, therefore, the harshness factor HF is limited into a narrow range of 3.2 to 3.5.

[0017] If HF is less than 3.2, the harshness noise can not reduce effectively. If HF is more than 3.5, the steering stability deteriorates.

#### Comparison Test

[0018] Test tyres having the structure shown in Fig.1 and specifications given in Table 1 were made by way of test and tested for vertical spring constant, harshness noise, and steering stability.

[0019] A 2800cc FR passenger car provided with test tyres was run on a dry asphalt test course, and the harshness noise and steering stability were evaluated by the driver's feelings.

[0020] The results are indicated in Table 1 by an index based on Ref.2 being 100, wherein the larger the value, the better the performance (Harshness noise and Steering stability).

Table 1

Tyre	Ex.1	Ex.2	Ref.1	Ref.2	Ref.3
Crown radius R1 (mm)	483	400	981	757	319
Shoulder radius R2(mm)	315	225	396	366	162
Vertical spring constant Kv (KN/mm)	20.6	18	23.3	20.3	14.1
Harshness factor HF	3.3	3.5	2.8	3	3.6
Harshness noise	108	110	95	100	115
Steering stability	94	97	105	100	90
Tyre size: 215/55R16					
Rim size: 16X7JJ (regular rim)					
Inner pressure: 200 KPa					

[0021] From the test results, it was confirmed that Example tyres according to the present invention can be improved in the harshness noise without deteriorating the steering stability.

## Claims

1. A pneumatic tyre for passenger cars comprising a tread portion (2), and when the tyre is mounted on its regular rim (J) and inflated to 200 KPa and loaded with no tyre load, said tread portion (2) has a profile comprising a crown part (Cr) having a radius of curvature R1 (mm) and shoulder parts (Sh) each having a radius of curvature R2 (mm), where said crown part (Cr) is defined as extending from the tyre equator (C) to an axial position (P1) on each side thereof spaced at an axial distance of 35 % of a tread width (TW) from the tyre equator (C), and each said shoulder part (Sh) is defined as extending on one side of the tyre equator from an axial position (P2) spaced at an axial distance of 37.5 % of the tread width (TW) from the tyre equator (C) to an axial position (P3) spaced at an axial distance of 45 % of the tread width (TW) from the tyre equator, characterised in that a harshness factor HF is set in the range of from 3.2 to 3.5, where said the harshness factor HF is defined as

$$HF = -0.133X(R1/100) + 0.245X(R1/R2) -$$

$$0.183X(Kv/10) + 3.898$$

and Kv is the vertical spring constant (KN/mm) of the tyre.

2. A pneumatic tyre according to claim 1, characterised in that said crown radius R1 is in the range of from 2 to 10 times the tread width (TW), and said shoulder radius R2 is smaller than the crown radius R1 and is in the range of from 1 to 5 times the tread width (TW).
3. A method of making a pneumatic tyre for passenger cars with reduced harshness noise, the method comprising a step of limiting a harshness factor HF to a value in the range of from 3.2 to 3.5, said harshness factor HF being defined as

$$HF = -0.133X(R1/100) + 0.245X(R1/R2) -$$

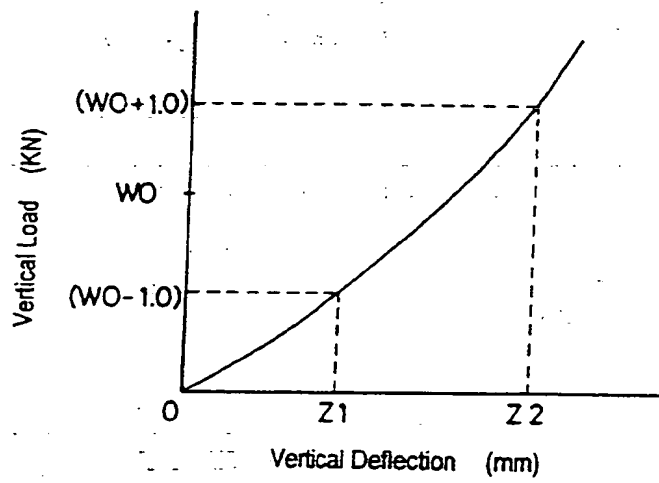
$$0.183X(Kv/10) + 3.898$$

wherein

R1 is the radius (mm) of curvature of a tread crown part (Cr), R2 is the radius (mm) of curvature of tread shoulder parts (Sh), Kv is the vertical spring constant (KN/mm) of the tyre, said tread crown part (Cr) being defined as extending from the tyre equator (C) to an axial position (P1) on each side thereof spaced at an axial distance of 35 % of a tread width (TW) from the tyre equator (C), and each said tread shoulder part being defined as extending on one side of the tyre equator from an axial position (P2) spaced at an axial distance of 37.5 % of the tread width (TW) from the tyre equator (C) to an axial position (P3) spaced at an axial distance of 45 % of the tread width (TW) from the tyre equator (C).



Fig.2





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(54) **Pneumatic tyre for passenger cars and method of manufacture thereof**

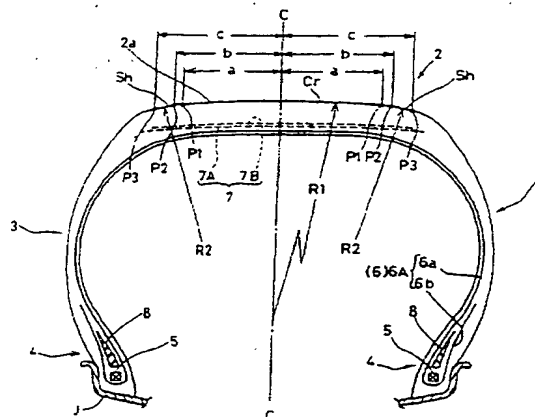
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where R1 is a radius of curvature (mm) of a crown part (Cr) of the tread profile, R2 is a radius of curvature (mm) of shoulder parts (Sh) of the tread profile, and Kv is the vertical spring constant (KN/mm) of the tyre.

**Fig. 1**





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# EUROPEAN SEARCH REPORT

Application Number  
EP 98 30 8972

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Place of search <b>THE HAGUE</b>		Date of completion of the search <b>9 August 2001</b>	Examiner <b>Baradat, J-L</b>
CATEGORY OF CITED DOCUMENTS X: particularly relevant if taken alone Y: particularly relevant if combined with another document of the same category A: technological background O: non-written disclosure P: intermediate document		T: theory or principle underlying the invention E: earlier patent document, but published on, or after the filing date D: document cited in the application L: document cited for other reasons &: member of the same patent family, corresponding document	

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